On-Orbit Vicarious Two Point Calibration of the GPM Radiometers

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Graphics from pmm.nasa.gov and authors except as noted

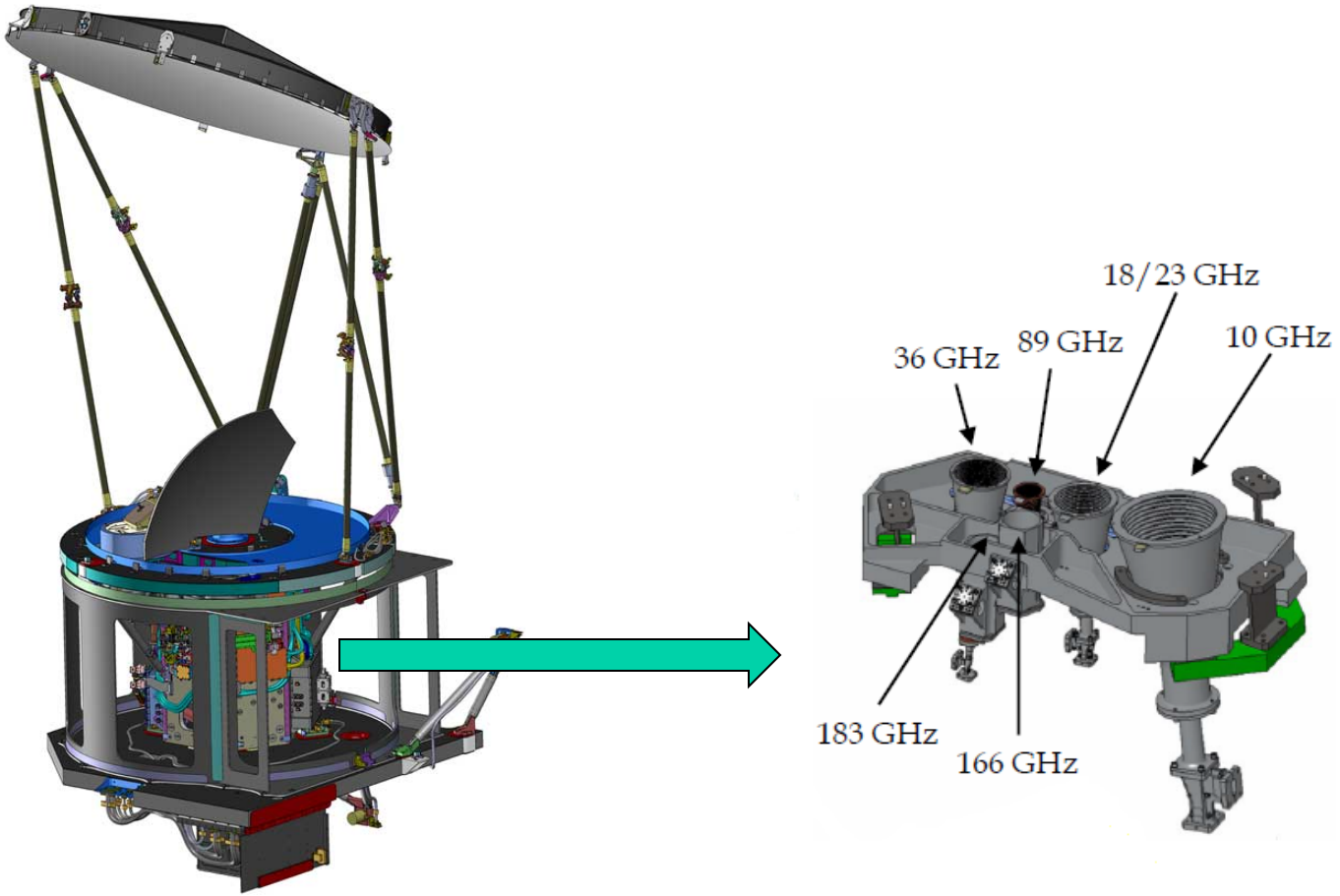
Xcal Process Overview

- First we pre-screen data
  - Remove outliers: sun glint, RFI, unphysical data, etc.
  - Look for attitude/pointing offsets
  - Look for calibration issues
    - Calibration load instabilities, reflector emission, receiver non-linearity, cross-pol leakage, etc.
    - APC inaccuracies, Scan biases
  - Investigate root cause, correct where possible
  - Want the cleanest data we can get before proceeding
- Then we intercalibrated
  - Determine offsets of each radiometer with respect to reference radiometer as a function of brightness temperature – Level 1C TB

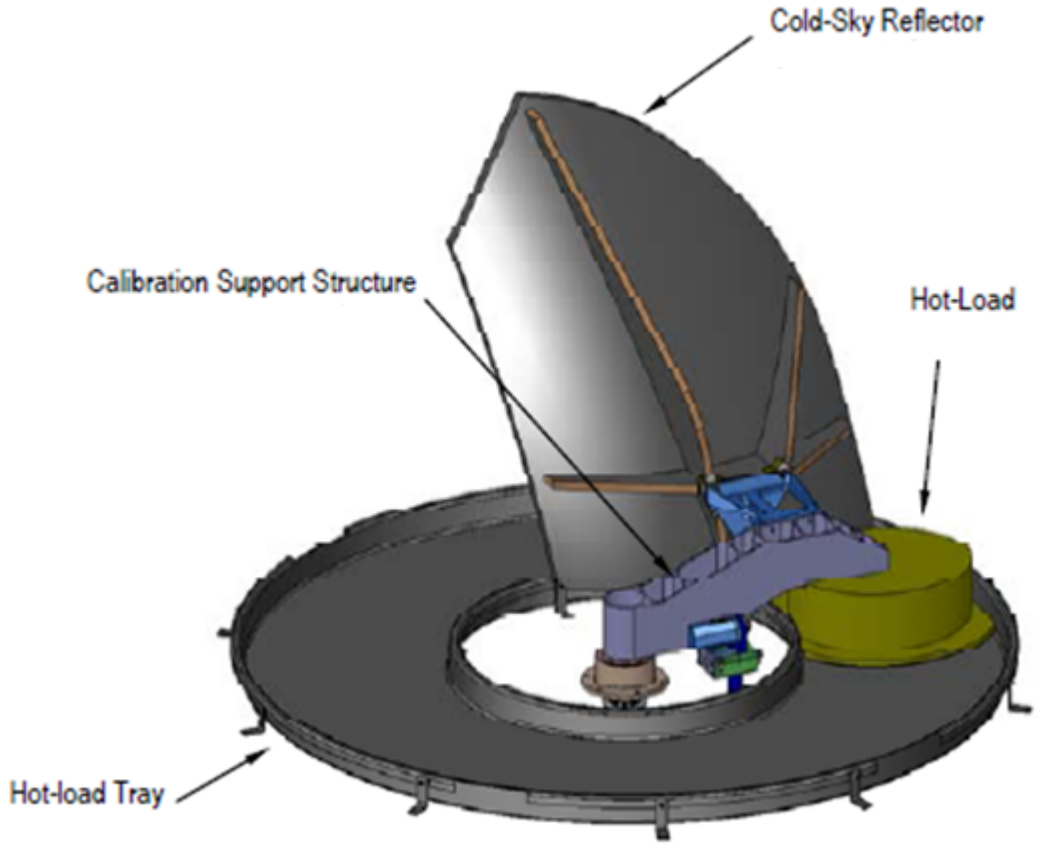
On-board Calibration vs. On-orbit Vicarious Calibration

- Each radiometer in the GPM constellation has an on-board calibration system
  - Convert between receiver counts and TB using targets of known brightness
    - For conical scanners (GMI, TMI, SSMIS, etc.), targets placed between receiver feedhorns and main reflector
    - Can't take into account antenna pattern effects
  - Use on-Earth observations with well-known TB to vicariously calibrate radiometer including reflector
    - Make updates to calibration that include antenna pattern effects, issues only seen on-orbit

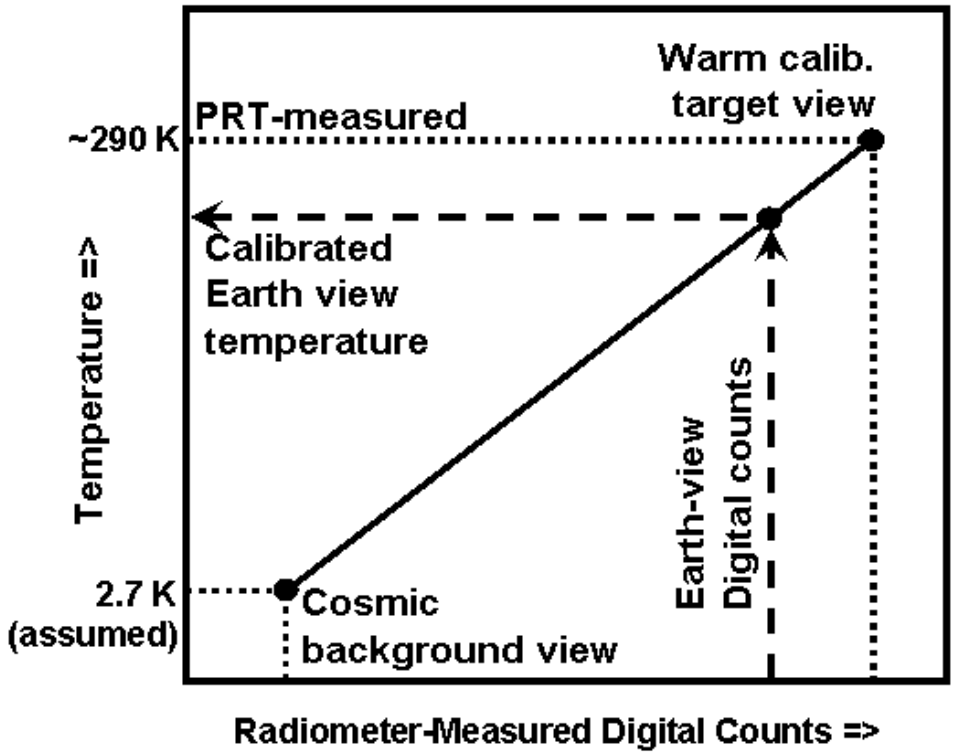
GPM Reference Radiometer - GMI



GMI Cold Sky Reflector and Warm Load



Radiometer Calibration: Cold Space and Warm Load Views



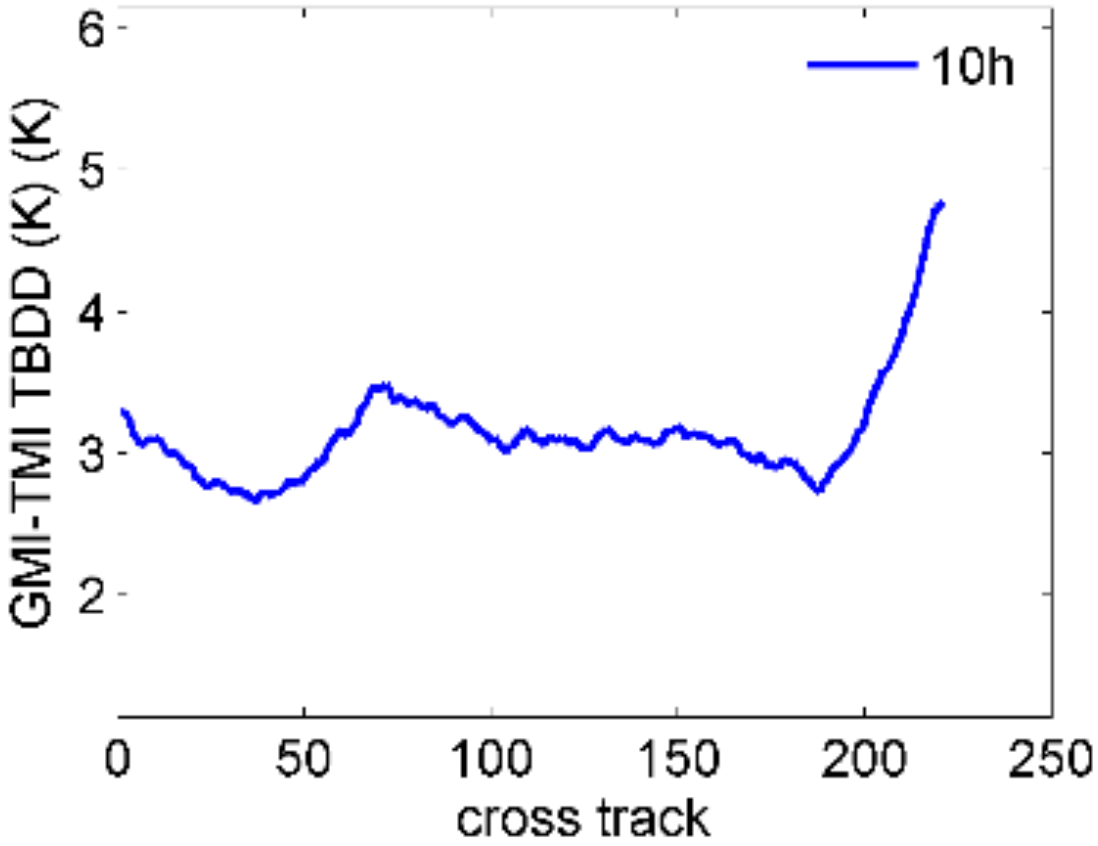
Vicarious Radiometer Calibration

- In order to improve radiometer calibration, use stable, on-Earth targets to assess quality of calibration for each constellation radiometer
  - Look for spatially extended, temporally stable areas with well understood, well modelled brightness
    - Average data over multiple regions, orbits to improve precision
  - Just as with on-orbit calibration, perform analysis at both cold and warm ends:
    - Cold end: Clear sky over ocean
    - Warm end: forests
      - Heavily vegetated, high emissivity, homogeneous

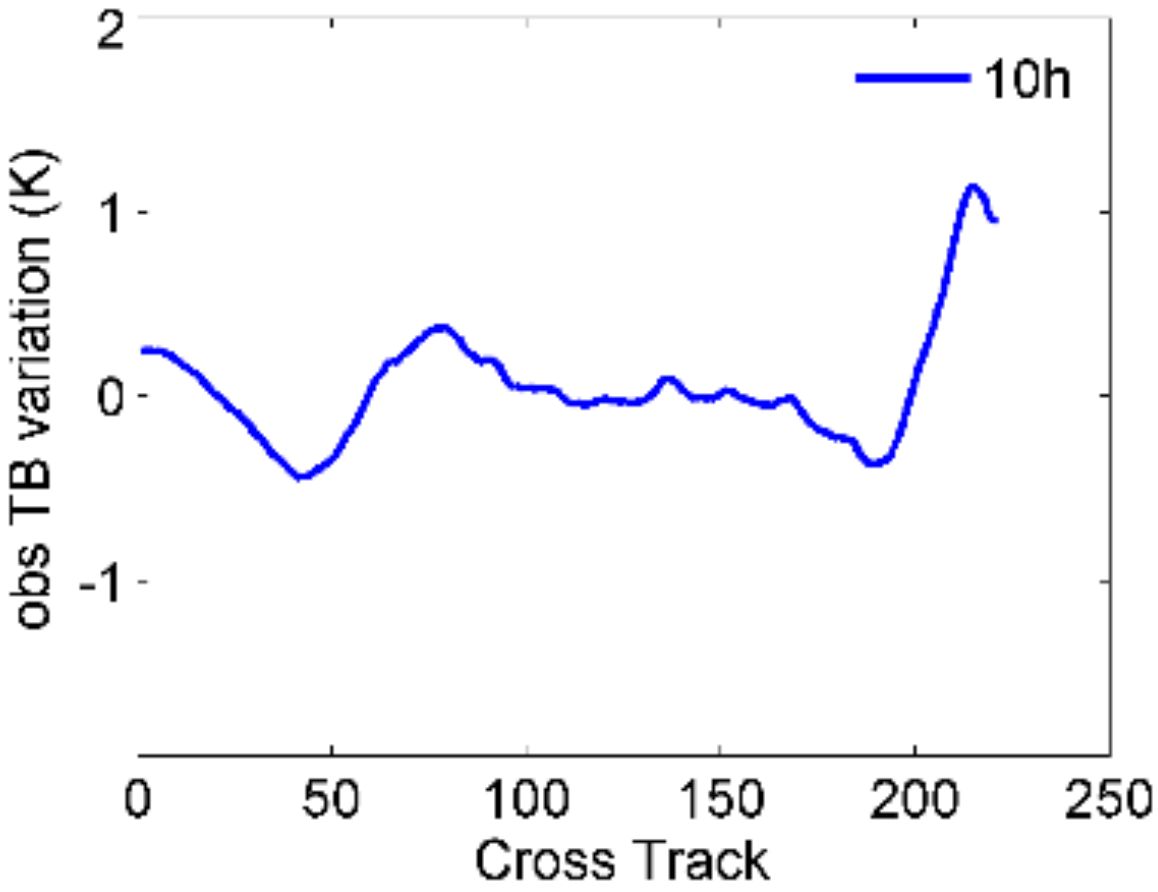
GMI Scan Biases and APC

- As with other radiometers, GMI has some scan biases
  - Biases as a function of scan position for observations over a uniform scene (TB vs scan position should be same but aren't)
  - Causes:
    - Edge of scan intrusions (calibration loads, spacecraft)
      - Main reflector sees sources of bias not seen by on-board calibration system
      - Impacted by APC/at antenna temperature level
    - Magnetic interference
      - On-board and Earth magnetic fields a source of scan position and orbit position dependent biases

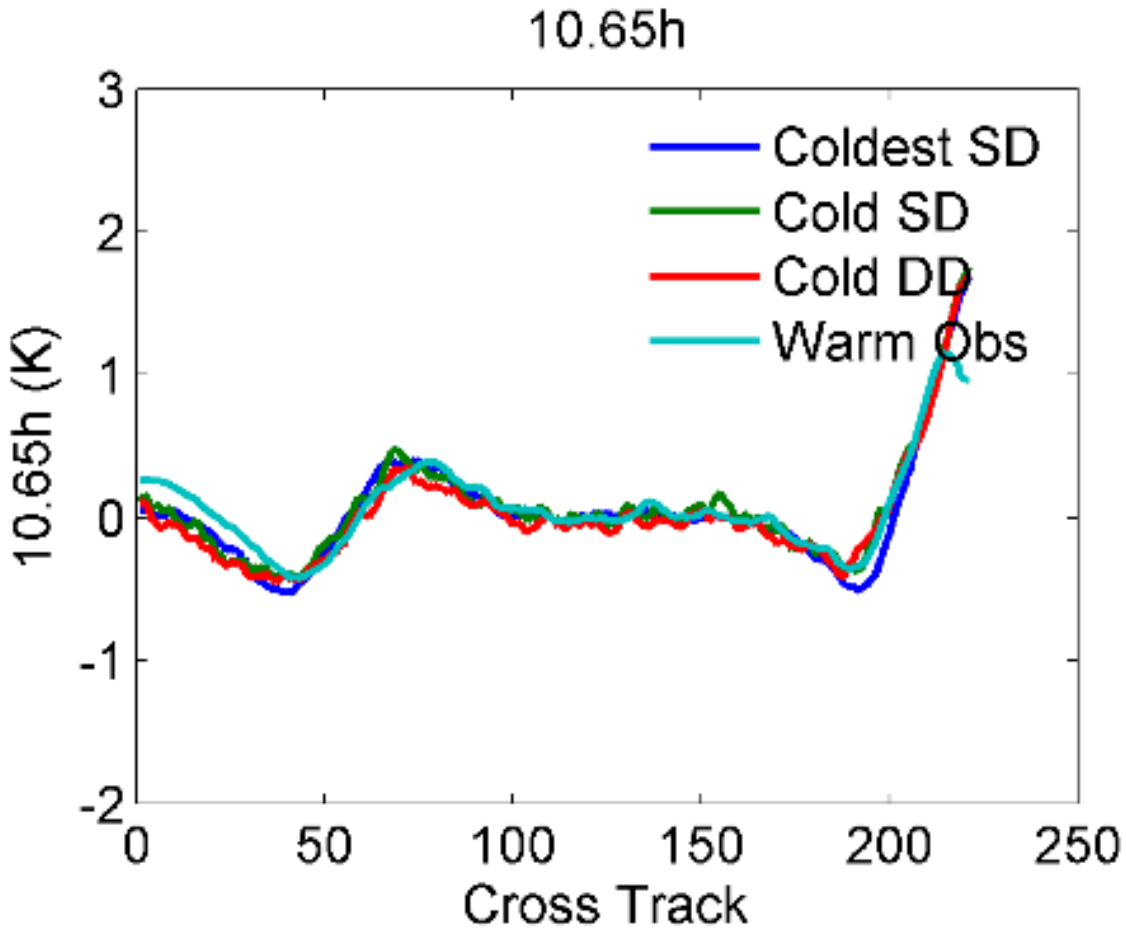
GMI Scan Biases, 10H
Cold End TBs Prior to Correction



GMI Scan Biases, 10H
Warm End TBs Prior to Correction



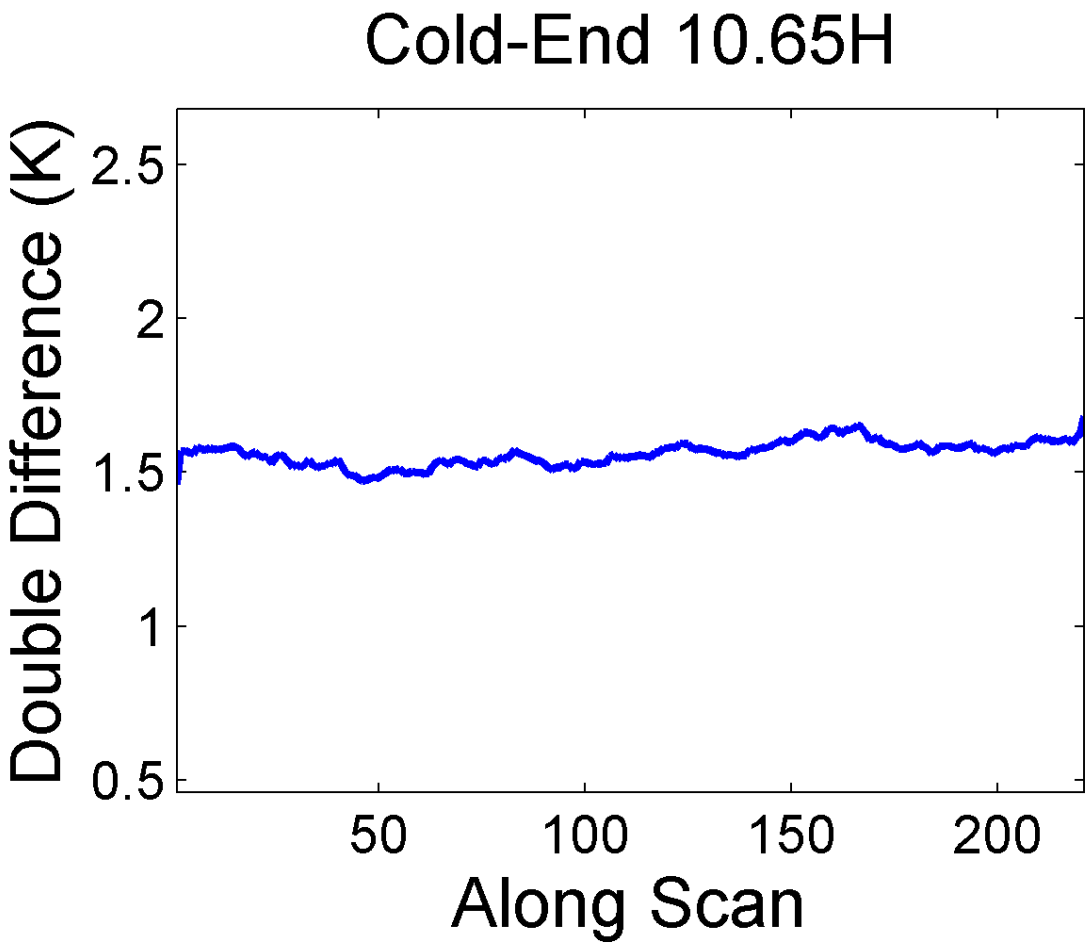
GMI Scan Biases, 10H
Composite Cold and Warm



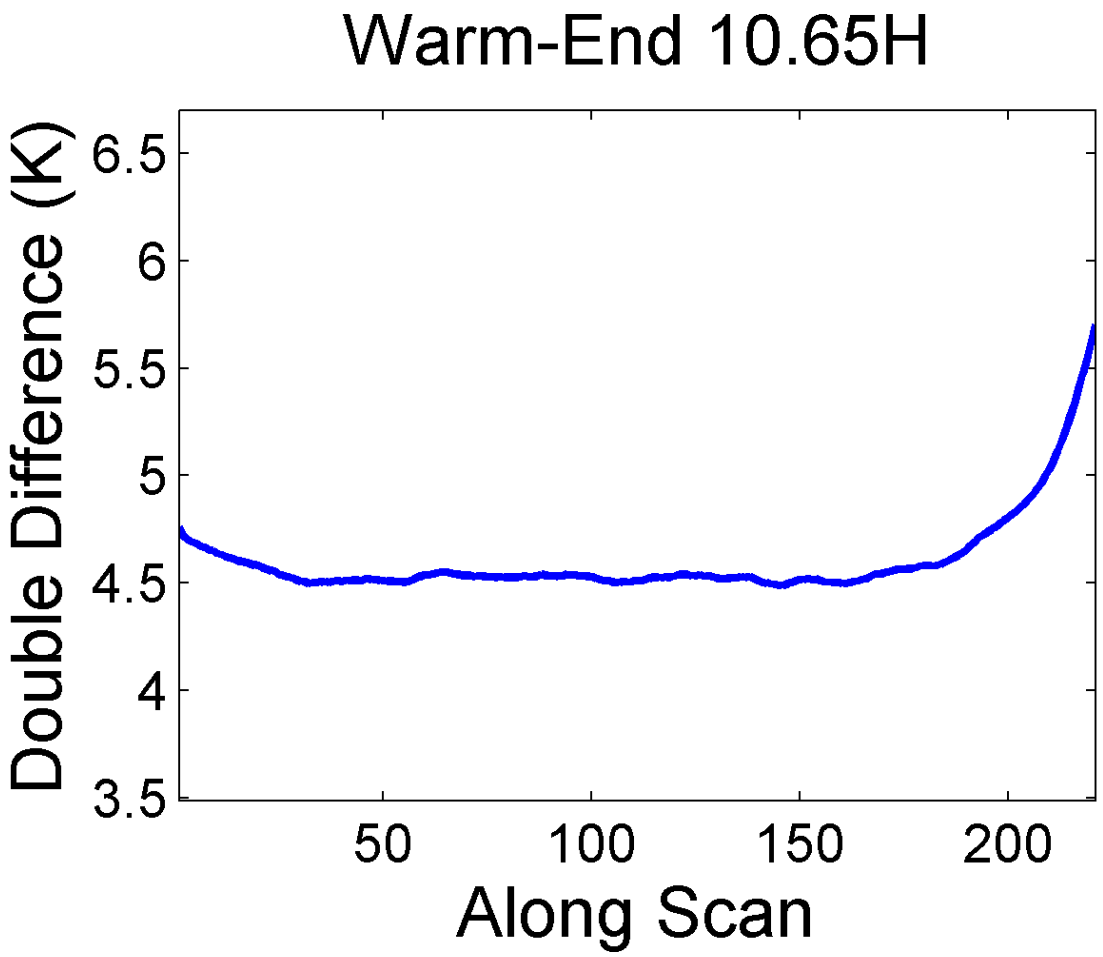
GMI Scan Bias Correction

- Ball/RSS developed initial scan bias correction
  - Uses combination of prelaunch characterization of magnetic interference, prediction of Earth's magnetic field, cold space maneuver, over-ocean analysis
    - No warm scene analysis used to look further into scan bias and APC correction as a function of scene TB – assumptions made to extrapolate to warm end
  - Before releasing in PPS, sent to Xcal for analysis of correction

GMI 10H, Cold Scenes with Initial Scan Bias Correction



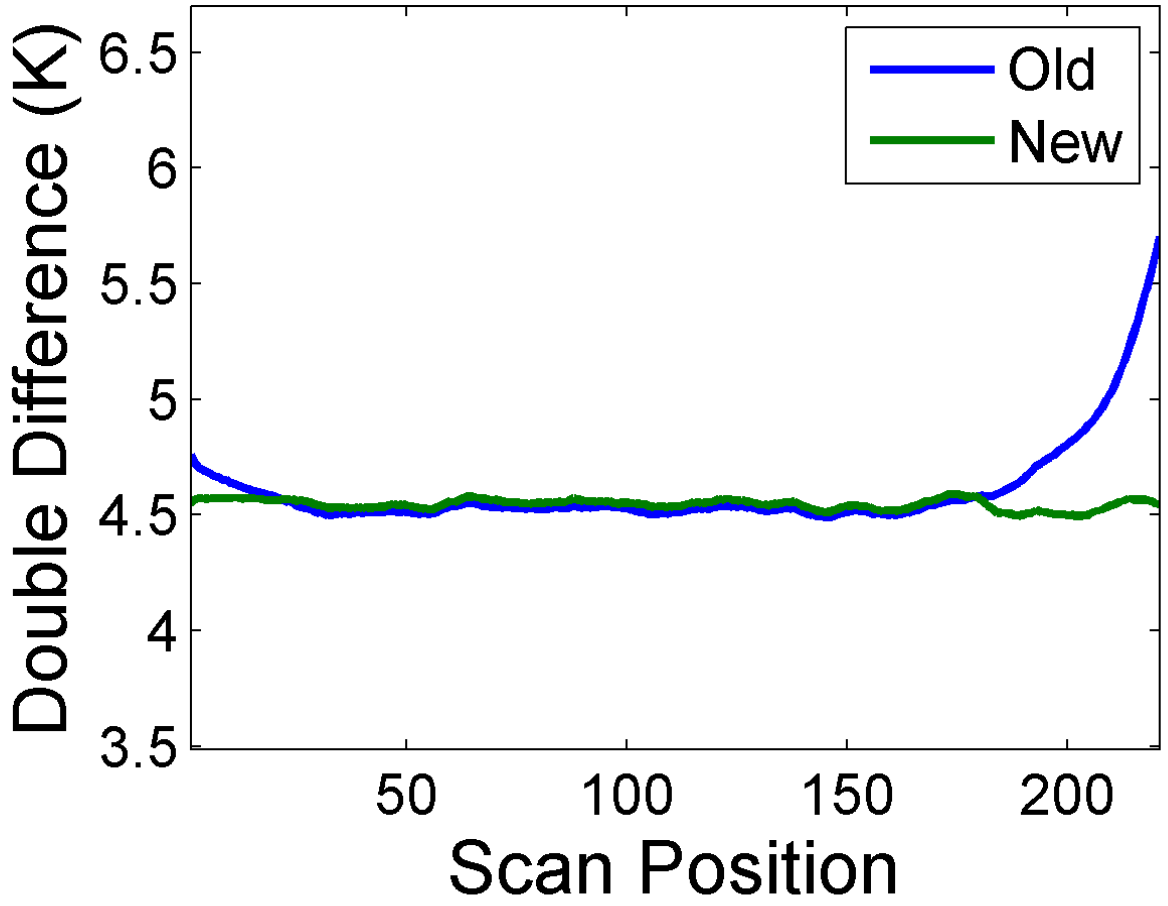
GMI 10H, Warm Scenes with Initial Scan Bias Correction



GMI Scan Bias Update

- We had well developed tools for warm end analysis not available to Ball/RSS
  - Based on vicarious warm calibration technique of Brown and Ruf developed over Amazon rainforest
    - Extended to include additional forested sites from tropics to mid-latitude to increase amount of data
    - Allowed for precise (low-noise) measurements of scan bias at warm end with fewer months of on-orbit data than original rainforest only method
    - Ball used UM warm data to update two point scan bias correction post-launch very early in mission

GMI 10H, Warm Scenes with Updated Scan Bias Correction



Summary
Xcal Prescreening on GMI Worked Well

- As part of Xcal process, group analyzes calibration of data to see if corrections are needed
  - Done at both cold and warm ends to mimic on-board calibration system to look at both gain and offset issues
  - Very useful for checking APC, scan bias corrections since done through main reflector
    - **UM analysis using latest warm end calibration technique used in Ball's two point scan bias correction for more accurate GMI data**
  - Will continue to refine/use techniques to monitor on-orbit performance, assess new radiometers, improve data quality